METHOD AND DEVICE FOR PROCESSING VIDEO DATA BY USING
SPECIFIC BORDER CODING

5   The present invention relates to a method for processing
video data to be displayed on a display screen by providing
said video data having video levels selected from a prede-
termined number of video levels, encoding said predetermined
number of video levels with a corresponding number of code-
10   words and illuminating pixels in a central area of said dis-
play screen in accordance with said codewords.

Furthermore, the present invention relates to a correspond-
ing device for processing video data.

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Background

Referring to the last generation of CRT displays, a lot of
work has been done to improve its picture quality. Conse-
20   quently, a new technology like Plasma has to provide a pic-
ture quality at least as good or even better than standard
CRT technology. For a TV consumer, high contrast is one main
factor for a high subjective picture quality of a given dis-
play. The dark room contrast is defined as the ratio between
25   the maximal luminance of the screen (peak-white) and the
black level. Today, on plasma display panels (PDP), contrast
values are inferior to those achieved for CRTs.

This limitation depends on two factors:

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- The brightness of the screen is limited by the panel effi-
cacy that in general is lower than that of a CRT for a
given power consumption. Nevertheless, the PDP efficacy
has been constantly improved during the last years for the
35   benefit of contrast.

- The black level of the PDP screen is not completely dark
  like on a CRT. In fact, a backlight is emitted even while
  displaying no video signal. The plasma technology requires
  for the successful writing of a cell a kind of pre-
5 excitation in the form of a regularly priming signal rep-
  resenting an overall pre-lighting of all plasma cells.
  This priming operation is responsible for the backlight,
  which drastically reduces the PDP contrast ratio. This re-
  duction is mostly visible in a dark room environment rep-
10 resenting the major situation for video applications (home
  theatre etc.)

In the following, aspects of response fidelity and priming
are presented in more detail.
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A panel having good response fidelity ensures that only one
pixel could be ON in the middle of a black screen and in ad-
dition, this panel has a good homogeneity. Figure 1 illus-
trates a white page displayed on PDP having response fidel-
20 ity problems. The response fidelity problems appear in the
form of misfiring of cells having too much inertia. Such
cells require more time for writing as available.

A first solution to achieve good response fidelity, by stan-
25 dard PDPs and for a given addressing speed, leads to the
priming operation mentioned above. In that case, each cell
will be repeatingly excited. Nevertheless, since an excita-
tion of a cell is characterized by an emission of light,
this has to be done parsimoniously to avoid a strong reduc-
30 tion of the dark room contrast (i.e. to avoid more back-
ground luminance). Therefore a simple way to improve the
dark room contrast leads to an optimization of the priming
use.

35 Actually, two kinds of priming can be found on the market:

- "Hard-priming" which generates more backlight (e.g. 0,8
  cd/m² but which has a very high efficacy. Usually, one
  single "hard priming" per video frame is sufficient.

5 - "Soft-priming" which generates less backlight (e.g. 0,1
  cd/m²) than the previous one but has less efficacy. On
  many products, this priming is used for each sub-field,
  which leads to a very poor dark room contrast again.

10 Obviously, the better solution should be based on the use of
  a "soft-priming" with the assumption that the total amount
  of "soft-priming" required to obtain an acceptable response
  fidelity will produce less light than a single "hard-
  priming". This is not the case when the coding has not been
15 optimized since one priming per sub-field should be re-
  quired.

  In fact, the best contrast ratio will be obtained by using a
  single soft-priming operation per frame. Such a concept is
20 achieved by optimization of the coding concept as seen in
  the next paragraph.

  The document EP-A-1 250 696 introduces a concept of one sin-
  gle "soft-priming", where only one priming at the beginning
25 of a frame is performed. In that case, only the first sub-
  fields will be near enough from the priming signal in the
  time domain to benefit from it. Now, the main idea was to
  use these first sub-fields as a kind of "artificial priming"
  for the next sub-fields taking the assumption that one
30 lighted sub-field will help the writing of the next ones
  (cascade effect). Figure 2 illustrates this "cascade effect"
  in the case of a 12 sub-fields code by analyzing the jitter
  of the writing discharge for the last sub-field (most sig-
  nificant bit MSB). It represents the statistic distribution
35 of the writing discharge of the last sub-field inside the
  plasma cell for two different codewords by respective enve-

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lope curves. In both situations, there is only one priming
(P) at the beginning of the frame (not shown).

In the first case, the codeword used (P-101111111101) en-
5   ables a good cascade effect from the priming P up to the
last sub-field (MSB). Then, the distribution of the writing
discharge is well concentrated and fully occur inside 1,1 µs
which represents the new borderline for the address speed.
This means, that the writing process can be performed within
10   the addressing period.

In the second case, the codeword used (P-000000000001) does
not permit any cascade effect and therefore the writing of
the last sub-field is less efficient. Then, the distribution
of the writing discharge is no more concentrated and is
15   spread on a longer time period as shown by the envelope.
Thus some writing process would be performed after the ad-
dressing period. In that case, more time should be given to
the addressing for acceptable response fidelity.

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The results presented in Figure 2 have shown that good re-
sponse fidelity can be obtained through a kind of cascade
effect from the priming up to the highest sub-field. In that
case the initialization started with the priming will spread
25   like a wild fire among the whole frame. Therefore, an opti-
mized concept will require a concentration of energy around
the low sub-fields, which are the most critical ones to en-
sure them a maximal benefit from the priming. In addition to
that, the time delay between two consecutives lighted sub-
30   fields should be kept as small as possible to increase the
influence between them and to produce an optimal cascade ef-
fect starting with the priming.

Figure 3 illustrates various ways to encode the video level
35   33 with two different sub-field organizations. Depending on
the sub-fields organization, there are one or more encoding
possibilities for a video value. A binary code shown on the

left side of Figure 3 leads to a large space between two
sub-fields ON. Therefore, there is no influence between
these sub-fields and no concentration of energy in the low
sub-fields. As a result, more priming or longer addressing
5   time is needed. A redundant code presented on the right side
of Figure 3 enables a better concentration of the energy
around the priming and also enables to reduce the distance
between two sub-fields ON so that the cascade effect can be
utilized.
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Moreover, the optimal sub-fields encoding should enable to
have not more than one sub-field OFF between two sub-fields
ON. This property will be called Single-O-Level (SOL). An
optimized sub-field weighting based on the mathematical Fi-
15   bonacci sequence enables to fully respect the SOL criterion.

Figure 4 illustrates an example of coding used for all fur-
ther explanations (11 sub-field redundant coding). The frame
depicted here starts with a priming operation. After that, a
20   sequence of sub-fields follows. Each sub-field starts with
an addressing block. According to the value of the sub-field
a time period for applying sustain impulses follows. At the
end of each sub-field a plasma cell is reset by an erasing
operation.
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Nevertheless, some experiments have shown that, under some
circumstances, even a SOL criterion combined with a single
"soft-priming" is not enough to provide perfect response fi-
delity.
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In the following the specific problem of the present inven-
tion is demonstrated. Experiments have shown that, when the
number of sustains grows, the biggest sub-fields will suffer
from response fidelity problems. These problems appear only
35   under certain circumstances, for instance in the case of a
horizontal greyscale at a high sustains number as shown in
Figure 5. When the number of sustains is increased, some re-

sponse fidelity problems appear at the PDP borders. However, this does not appear in a homogeneous way but only some specific video levels are disturbed.

5   Invention

In view of that it is the object of the present invention to provide a method and device for processing video data, which remove the PDP border problem.

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According to the present invention this object is solved by a method for processing video data to be displayed on a display screen by providing said video data having video levels selected from a predetermined number of video levels, encod-
15 ing said predetermined number of video levels with a corresponding number of codewords and illuminating pixels in a central area of said display screen in accordance with said codewords, as well as illuminating pixels in a border area surrounding said central area of said display screen by us-
20 ing only those codewords of said number of codewords, which have a constant bit value in a selectable part of the codewords.

Furthermore, according to the present invention there is
25 provided a device for processing video data to be displayed on a display screen including data providing means for providing said video data having video levels selected from a predetermined number of video levels, encoding means for encoding said predetermined number of video levels with a cor-
30 responding number of codewords and illuminating means for illuminating pixels in a central area of said display screen in accordance with said codewords, wherein said illuminating means is adapted for illuminating pixels in a border area surrounding said central area of said display screen by us-
35 ing only those codewords of said number of codewords, which have a constant bit value in a selectable part of the codewords.

Preferably, codewords, which have a binary 0 between two bi-
nary 1, are not used for illuminating the border area. Thus,
cells of the display screen being ON cannot pollute sur-

5   rounding cells being OFF.

Video levels corresponding to codewords being not used may
be recreated by dithering. With such dithering every video
level can be created by temporarily switching on an off a

10   higher video level.

In a preferred embodiment a part of the codewords having
constant bit value may be determined by a power level of a
picture to be displayed. Since the pollution of neighbour

15   cells depends on the power level of a picture, it is advan-
tageous to adapt the coding of the video levels to the power
level.

Moreover, the part of the codewords being determined to have

20   constant bit value should include the most significant bits
of the codewords. Thus, especially those codewords are not
used for coding video levels, the high level sub-fields of
which are on and off alternatingly. Consequently, cells of
the display screen being energized by a lot of sustain im-

25   pulses according to high level sub-fields will not pollute
neighbouring cells being OFF.

The border problem is reduced towards the centre of the dis-
play screen. Therefore, the border area is preferably di-

30   vided into several sub-areas, wherein the non-usage of code-
words is stepwise reduced. A first one of said several sub-
areas may be illuminated by codewords with a first select-
able part of constant bit value and a second one of the sev-
eral sub-areas may be illuminated by codewords with a second

35   selectable part of constant bit value, wherein the second
selectable part includes the first selectable part of code-
words or at least a portion of it or is different from the

first selectable part. In a preferred embodiment the length
of the part within a codeword in which the bit value is con-
stant, is variable starting from the most significant bit of
a codeword.

Drawings

Exemplary embodiments of the invention are illustrated in
the drawings and are explained in more detail in the follow-
ing description. The drawings showing in:

Fig. 1   a dual-scan PDP having response fidelity problems;

Fig. 2   a cascade effect for last sub-field writing;

Fig. 3   various coding possibilities towards a single-0-
            concept;

Fig. 4   an example of the single soft-priming concept;

Fig. 5   a typical PDP border problem;

Fig. 6   the structure of a PDP before sealing;

Fig. 7   the structure of a PDP after sealing;

Fig. 8   a zoomed part of Figure 5 having the border prob-
            lem;

Fig. 9   a codeword comparison of the codewords of Figure
            8;

Fig. 10   a zoomed part of Figure 5 having no border prob-
            lems;

Fig. 11   a codeword comparison of codewords of Figure 10;

Fig. 12   an ON/OFF pattern in case of closed cells of a
             display screen;

Fig 13.   an ON/OFF pattern in case of open cells of a dis-
             play screen;

Fig. 14   a general concept of a power management;

Fig. 15   a function showing the linkage between the power
             consumption and the number of sustains per frame
             for a power management applied to a PDP;

Fig. 16   an evolution of sustain sequence versus the aver-
             age power level;

Fig. 17   critical sub-field for response fidelity;

Fig. 18   display screens with different border areas; and

Fig. 19   a block diagram of a hardware implementation of a
             device according to the present invention.

Exemplary embodiments

The present invention is based on the knowledge that the
structure of a PDP in its centre is different from that in
the border area. In detail plasma panels are built with two
glass plates (front and back) sealed together and having
electrodes on top of them (horizontal transparent electrodes
on the front plate, vertical metallic electrodes on the back
plate). The various plasma cells (Red, Green and Blue dots)
are delimited through so-called barrier-ribs having a cer-
tain height. This height also normally defines the distance
between the two plates. This basic concept is illustrated in
Figure 6 for a PDP sealing. There is a height difference be-
tween the ribs and the seal being arranged at the border of
the plasma panel. Indeed, in order to have a perfect seal-

ing, it is needed that the seal is higher than the ribs. On
the other side, the precision in this height is not very
fine today and will also depend on the sealing process. In-
deed, during that process, the seal will be molten. The re-

5   sult of the sealing process is shown in Figure 7. In the
middle of the screen (far from the seal) the cells are com-
pletely closed, whereas, at the border of the screen, near
the seal, the cells are open.

10   This geometrical situation will have a strong impact on the
panel response fidelity, above all for very energetic pic-
tures (pictures with a lot of sustains).

In the introductory part the concept enabling the use of

15   only one single priming operation in the case of an opti-
mized encoding has been presented. This concept of single
priming works very well in case of full-white pictures hav-
ing a limited maximal white value (e.g. 100 cd./m^2 with
around 150 sustains). In that case, since the soft-priming

20   light emission is below 0.1 cd/m^2 the contrast ratio is be-
yond 1000:1 in dark room.

However, as illustrated in Figure 5, when the number of sus-
tain impulses grows, the biggest sub-field suffers from re-

25   sponse fidelity problems e.g. in the case of a horizontal
greyscale at the border of the PDP. In order to examine
these response fidelity problems, a zoomed part of the
screen is illustrated in Figure 8. A greyscale is realized
by a smooth transitation from the pixel value 170 to the

30   pixel value 176 by displaying the values alternatingly. The
following sub-field code is used:

1-2-3-5-8-12-18-24-31-40-50-61.

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Figure 8 shows that the response fidelity problems, in the
example, are located at the cells having direct neighbours

with different values. In other words, when a cell with the
value 170 has a direct neighbour (not diagonal) having the
value 176, both cells have problems.

5   In order to learn the reasons of the problems the sub-field
codewords for these values should be compared. The compari-
son is shown in Figure 9. Differences are given in the sev-
enth and eighth bit.

10   Now, in order to learn more about the reason of the problems
another zoomed part of the screen is shown in Figure 10. As
apparent from this Figure there are no cells having prob-
lems. A comparison of the codewords related to Figure 10 is
illustrated in Figure 11. Differences appear in the second
15   and third bit.

The examples given above show that the problem of response
fidelity appearing at a PDP border for high video level pic-
tures are linked to the switching ON/OFF of MSB. Indeed, in
20   the case presented Figure 8 showing artefacts, the differ-
ences between the video values 170 and 176 are located on
the sub-fields 7 and 8. However, in the case presented in
Figure 10 showing no artefacts, the differences are located
only in the LSBs.
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This problem is directly linked to the situation described
above: the open cells at the PDP border. Indeed, when an
open cell has a certain sub-field switched ON, it will pol-
lute the neighbouring cells that are OFF (compare Figure
30   13). This is not the case for closed cells as immediately
apparent from Figure 12. The cells switched ON do not influ-
ence neighbouring cells switched OFF.

The examples above show that, when a cell is open, there
35   could be a migration of charges to the neighbouring cells.
When those neighbours are ON, the migration will disappear
during a discharging operation. However, when the neighbour-

ing cells are OFF, the charges will remain. The amount of
charges will depend on the number of sustains used for the
sub-field ON. Then, if the amount of polluting charges is
strong enough, this could disturb the writing of the next
5   sub-field for the polluted cells.

Up to a certain degree this pollution problem can be solved
by applying priming operation, since the priming operation
acts as reset and is able to suppress the polluting charges.
10   In order to do that, this concept described in EP-A-1 335
341 is based on a limit Δ representing a maximal number of
sustain without priming. In other words, when a sub-field
contains more than Δ sustains, its priming is activated.
This leads to an evolving number of priming. However, this
15   also reduces the maximal available darkroom contrast.

In order to go further and to reduce the total amount of
priming, according to the present invention it is suggested
to modify the codeword at the panel border so that critical
20   situations like that depicted in Figure 5 can no more hap-
pen.

The codewords may be modified in dependence of the average
power level of a picture to be displayed. A prerequisite of
25   this is that an adequate power management is provided.

For every kind of active display, more peak luminance corre-
sponds also to a higher power that flows in the electronic.
Therefore, if no specific management is done, the enhance-
30   ment of the peak luminance for a given electronic efficacy
will introduce an increase of the power consumption. The
main idea behind every kind of power management concept as-
sociated with peak white enhancement is based on the varia-
tion of the peak-luminance depending on the picture content
35   in order to stabilize the power consumption to a specified
value. This is illustrated in Figure 14. The concept enables
to avoid any overloading of the power-supply as well as a

maximum contrast for a given picture. In the case of ana-
logue displays like CRTs, the power management is based on a
so called ABM function (Average Beam-current Limiter), which
is implemented by analogue means, and which decreases video
5   gain as a function of average luminance, usually measured
over a RC stage. In the case of a plasma display, the lumi-
nance, i.e. the picture charge, as well as the power con-
sumption is directly linked to the number of sustains (light
pulse) per frame as shown in Figure 15.

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In order to avoid overloading the power supply of the
plasma, the number of sustains can be adjusted depending on
the picture content. When the picture is full (e.g. full
white page – 100%) it is not possible to use the total
15   amount of sustains (e.g. only 100 sustains are used) which
leads to a reduced white luminance (around 100 cd/m2). This
determines the power consumption (e.g. 300 W). Then when the
charge of the picture decreases (e.g. night with only a
small moon up to 0%), the number of sustains can be in-
20   creased without increasing the power consumption. This only
enhances the contrast for the human eye.

In other words, for every charge of the input picture com-
puted through the APL (Average Power Level), a certain
25   amount of sustain impulses will be used for the peak white
as shown in Figure 15. This has the disadvantage of allowing
only a reduced number of discrete power levels compared to
an analogue system. The computation of the image energy
(APL) is made through the following function:

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$$APL(I(x,y)) = \frac{1}{C \times L} \cdot \sum_{x,y} I(x,y)$$

where I(x,y) represents the picture to be displayed, C the
number of columns and L the number of lines of this picture.
35   Then, for every possible APL values, the maximal number of
sustains to be used is fixed.

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Since, only an integer number of sustains can be used, there
is only a limited number of available APL levels. This is
illustrated in Figure 16 representing the sustain sequences
5   for various APL levels at a given sub-fields sequence based
on a 12 sub-fields Fibonacci sequence: 1-2-3-5-8-13-19-25-
32-40-49-58

According to Figure 15 the number of sustains for a given
10   sub-field is changing a lot. If one considers the case of a
limit value $\Delta=55$ of sustains under which there is no pollut-
ing problem, one can easily detect the sub-fields showing
critical behaviour as shown in Figure 17. The sub-fields
showing response fidelity problems are marked with grey col-
15   our. In the case of EP-A-1 335 341, these sub-fields repre-
sent the sub-fields, which would be primed. However, accord-
ing to the present new concept, the codewords related to
these sub-fields will be modified (depending on the APL
situation). Obviously, this codeword modification will only
20   be performed on the sub-fields showing problems at the mo-
ment where a modification is needed: there is no need to
make any modification for APL=100% whereas seven sub-fields
could be affected for APL=0%.

25   An other important aspect of the present new concept of
codeword modification is its compatibility with the previous
concept of dynamic priming. Indeed, both concepts can be
utilized separately but a combination of both brings further
improvements. On one hand, dynamic priming increases the
30   dark level (reducing the darkroom contrast) without modify-
ing the greyscale quality, on the other hand the concept of
codeword modification limits the greyscale portrayal capa-
bility of the plasma panel in border areas while requiring
no additional priming.
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As already said, the inventive concept is based on a spe-
cific encoding for border areas. Figure 18 illustrates the

concept of border areas surrounding a standard area with two
possibilities:

- Only one border area is used having a single limit Δ used
  for the codeword limitation (left side of Figure 18).

- Multiple border areas are defined, each of them having
  their independent limit Δ1, Δ2, Δ3 with Δ1< Δ2<Δ3 since
  the polluting level is reducing while moving away from the
  screen border (right side of Figure 18).

It is important to notice here that the border areas are
really small and do not represent a main part of the screen
(e.g. only 4% of the screen).

In the following the basic concept of codeword limitation
shall be explained in detail. For this, the example defined
in Figure 16 for the case of APL=0% and for the three limits
Δ1, Δ2, Δ3 in case of multiple border areas will be util-
ized. The following limit values are chosen.

Δ1=55
Δ2=90
Δ3=120

In fact, the values are obtained through measurements at the
panel level.

The main idea behind this concept is to forbid the insertion
of 0 between two 1 for critical sub-fields. In other words,
in the total amount of existing codewords, the critical ones
will be suppressed. In the following table one can find the
standard encoding table for the sub-field sequences used
above: 1-2-3-5-8-13-19-25-32-40-49-58 as well as the sup-
pressed codewords for all areas.

Table: Coding of three border areas

Video value	Codeword standard	Codeword for Δ_3	Codeword for Δ_2	Codeword for Δ_1
0	000000000000	000000000000	000000000000	000000000000
1	100000000000	100000000000	100000000000	100000000000
2	010000000000	010000000000	010000000000	010000000000
3	110000000000	110000000000	110000000000	110000000000
4	101000000000	101000000000	101000000000	101000000000
5	011000000000	011000000000	011000000000	011000000000
6	111000000000	111000000000	111000000000	111000000000
7	010100000000	010100000000	010100000000	010100000000
8	110100000000	110100000000	110100000000	110100000000
9	101100000000	101100000000	101100000000	101100000000
10	011100000000	011100000000	011100000000	011100000000
11	111100000000	111100000000	111100000000	111100000000
12	101010000000	101010000000	101010000000	101010000000
13	011010000000	011010000000	011010000000	011010000000
14	111010000000	111010000000	111010000000	111010000000
15	010110000000	010110000000	010110000000	010110000000
16	110110000000	110110000000	110110000000	110110000000
17	101110000000	101110000000	101110000000	101110000000
18	011110000000	011110000000	011110000000	011110000000
19	111110000000	111110000000	111110000000	111110000000
20	010101000000	010101000000	010101000000	010101000000
21	110101000000	110101000000	110101000000	110101000000
22	101101000000	101101000000	101101000000	101101000000
23	011101000000	011101000000	011101000000	011101000000
24	111101000000	111101000000	111101000000	111101000000
25	101011000000	101011000000	101011000000	101011000000
26	011011000000	011011000000	011011000000	011011000000
27	111011000000	111011000000	111011000000	111011000000
28	010111000000	010111000000	010111000000	010111000000
29	110111000000	110111000000	110111000000	110111000000
30	101111000000	101111000000	101111000000	101111000000
31	011111000000	011111000000	011111000000	011111000000
32	111111000000	111111000000	111111000000	111111000000
33	111010100000	111010100000	111010100000	XXXXXXXXXXXX
34	010110100000	010110100000	010110100000	XXXXXXXXXXXX
35	110110100000	110110100000	110110100000	XXXXXXXXXXXX
36	101110100000	101110100000	101110100000	XXXXXXXXXXXX
37	011110100000	011110100000	011110100000	XXXXXXXXXXXX
38	111110100000	111110100000	111110100000	XXXXXXXXXXXX
39	010101100000	010101100000	010101100000	010101100000
40	110101100000	110101100000	110101100000	110101100000
41	101101100000	101101100000	101101100000	101101100000
42	011101100000	011101100000	011101100000	011101100000
43	111101100000	111101100000	111101100000	111101100000
44	101011100000	101011100000	101011100000	101011100000
45	011011100000	011011100000	011011100000	011011100000
46	111011100000	111011100000	111011100000	111011100000
47	010111100000	010111100000	010111100000	010111100000
48	110111100000	110111100000	110111100000	110111100000
49	101111100000	101111100000	101111100000	101111100000
50	011111100000	011111100000	011111100000	011111100000
51	111111100000	111111100000	111111100000	111111100000
52	111011010000	111011010000	XXXXXXXXXXXX	XXXXXXXXXXXX

53	010111010000	010111010000	XXXXXXXXXX	XXXXXXXXXX
54	110111010000	110111010000	XXXXXXXXXX	XXXXXXXXXX
55	101111010000	101111010000	XXXXXXXXXX	XXXXXXXXXX
56	011111010000	011111010000	XXXXXXXXXX	XXXXXXXXXX
57	111111010000	111111010000	XXXXXXXXXX	XXXXXXXXXX
58	111010110000	111010110000	111010110000	XXXXXXXXXX
59	010110110000	010110110000	010110110000	XXXXXXXXXX
60	110110110000	110110110000	110110110000	XXXXXXXXXX
61	101110110000	101110110000	101110110000	XXXXXXXXXX
62	011110110000	011110110000	011110110000	XXXXXXXXXX
63	111110110000	111110110000	111110110000	XXXXXXXXXX
64	010101110000	010101110000	010101110000	010101110000
65	110101110000	110101110000	110101110000	110101110000
66	101101110000	101101110000	101101110000	101101110000
67	011101110000	011101110000	011101110000	011101110000
68	111101110000	111101110000	111101110000	111101110000
69	101011110000	101011110000	101011110000	101011110000
70	011011110000	011011110000	011011110000	011011110000
71	111011110000	111011110000	111011110000	111011110000
72	010111110000	010111110000	010111110000	010111110000
73	110111110000	110111110000	110111110000	110111110000
74	101111110000	101111110000	101111110000	101111110000
75	011111110000	011111110000	011111110000	011111110000
76	111111110000	111111110000	111111110000	111111110000
77	011011101000	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
78	111011101000	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
79	010111101000	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
80	110111101000	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
81	101111101000	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
82	011111101000	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
83	111111101000	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
84	111011011000	111011011000	XXXXXXXXXX	XXXXXXXXXX
85	010111011000	010111011000	XXXXXXXXXX	XXXXXXXXXX
86	110111011000	110111011000	XXXXXXXXXX	XXXXXXXXXX
87	101111011000	101111011000	XXXXXXXXXX	XXXXXXXXXX
88	011111011000	011111011000	XXXXXXXXXX	XXXXXXXXXX
89	111111011000	111111011000	XXXXXXXXXX	XXXXXXXXXX
90	111010111000	111010111000	111010111000	XXXXXXXXXX
91	010110111000	010110111000	010110111000	XXXXXXXXXX
92	110110111000	110110111000	110110111000	XXXXXXXXXX
93	101110111000	101110111000	101110111000	XXXXXXXXXX
94	011110111000	011110111000	011110111000	XXXXXXXXXX
95	111110111000	111110111000	111110111000	XXXXXXXXXX
96	010101111000	010101111000	010101111000	010101111000
97	110101111000	110101111000	110101111000	110101111000
98	101101111000	101101111000	101101111000	101101111000
99	011101111000	011101111000	011101111000	011101111000
100	111101111000	111101111000	111101111000	111101111000
101	101011111000	101011111000	101011111000	101011111000
102	011011111000	011011111000	011011111000	011011111000
103	111011111000	111011111000	111011111000	111011111000
104	010111111000	010111111000	010111111000	010111111000
105	110111111000	110111111000	110111111000	110111111000
106	101111111000	101111111000	101111111000	101111111000
107	011111111000	011111111000	011111111000	011111111000
108	111111111000	111111111000	111111111000	111111111000
109	101011110100	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
110	011011110100	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX

111	111011110100	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
112	010111110100	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
113	110111110100	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
114	101111110100	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
115	011111110100	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
116	111111110100	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
117	011011101100	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
118	111011101100	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
119	010111101100	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
120	110111101100	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
121	101111101100	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
122	011111101100	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
123	111111101100	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
124	111011011100	111011011100	XXXXXXXXXX	XXXXXXXXXX
125	010111011100	010111011100	XXXXXXXXXX	XXXXXXXXXX
126	110111011100	110111011100	XXXXXXXXXX	XXXXXXXXXX
127	101111011100	101111011100	XXXXXXXXXX	XXXXXXXXXX
128	011111011100	011111011100	XXXXXXXXXX	XXXXXXXXXX
129	111111011100	111111011100	XXXXXXXXXX	XXXXXXXXXX
130	111010111100	111010111100	111010111100	XXXXXXXXXX
131	010110111100	010110111100	010110111100	XXXXXXXXXX
132	110110111100	110110111100	110110111100	XXXXXXXXXX
133	101110111100	101110111100	101110111100	XXXXXXXXXX
134	011110111100	011110111100	011110111100	XXXXXXXXXX
135	111110111100	111110111100	111110111100	XXXXXXXXXX
136	010101111100	010101111100	010101111100	010101111100
137	110101111100	110101111100	110101111100	110101111100
138	101101111100	101101111100	101101111100	101101111100
139	011101111100	011101111100	011101111100	011101111100
140	111101111100	111101111100	111101111100	111101111100
141	101011111100	101011111100	101011111100	101011111100
142	011011111100	011011111100	011011111100	011011111100
143	111011111100	111011111100	111011111100	111011111100
144	010111111100	010111111100	010111111100	010111111100
145	110111111100	110111111100	110111111100	110111111100
146	101111111100	101111111100	101111111100	101111111100
147	011111111100	011111111100	011111111100	011111111100
148	111111111100	111111111100	111111111100	111111111100
149	111101111010	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
150	101011111010	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
151	011011111010	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
152	111011111010	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
153	010111111010	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
154	110111111010	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
155	101111111010	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
156	011111111010	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
157	111111111010	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
158	101011110110	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
159	011011110110	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
160	111011110110	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
161	010111110110	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
162	110111110110	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
163	101111110110	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
164	011111110110	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
165	111111110110	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
166	011011101110	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
167	111011101110	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
168	010111101110	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX

169	110111101110	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
170	101111101110	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
171	011111101110	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
172	111111101110	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
173	111011011110	111011011110	XXXXXXXXXX	XXXXXXXXXX
174	010111011110	010111011110	XXXXXXXXXX	XXXXXXXXXX
175	110111011110	110111011110	XXXXXXXXXX	XXXXXXXXXX
176	101111011110	101111011110	XXXXXXXXXX	XXXXXXXXXX
177	011111011110	011111011110	XXXXXXXXXX	XXXXXXXXXX
178	111111011110	111111011110	XXXXXXXXXX	XXXXXXXXXX
179	111010111110	111010111110	111010111110	XXXXXXXXXX
180	010110111110	010110111110	010110111110	XXXXXXXXXX
181	110110111110	110110111110	110110111110	XXXXXXXXXX
182	101110111110	101110111110	101110111110	XXXXXXXXXX
183	011110111110	011110111110	011110111110	XXXXXXXXXX
184	111110111110	111110111110	111110111110	XXXXXXXXXX
185	010101111110	010101111110	010101111110	010101111110
186	110101111110	110101111110	110101111110	110101111110
187	101101111110	101101111110	101101111110	101101111110
188	011101111110	011101111110	011101111110	011101111110
189	111101111110	111101111110	111101111110	111101111110
190	101011111110	101011111110	101011111110	101011111110
191	011011111110	011011111110	011011111110	011011111110
192	111011111110	111011111110	111011111110	111011111110
193	010111111110	010111111110	010111111110	010111111110
194	110111111110	110111111110	110111111110	110111111110
195	101111111110	101111111110	101111111110	101111111110
196	011111111110	011111111110	011111111110	011111111110
197	111111111110	111111111110	111111111110	111111111110
198	111101111101	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
199	101011111101	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
200	011011111101	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
201	111011111101	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
202	010111111101	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
203	110111111101	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
204	101111111101	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
205	011111111101	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
206	111111111101	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
207	111101111011	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
208	101011111011	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
209	011011111011	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
210	111011111011	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
211	010111111011	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
212	110111111011	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
213	101111111011	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
214	011111111011	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
215	111111111011	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
216	101011110111	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
217	011011110111	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
218	111011110111	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
219	010111110111	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
220	110111110111	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
221	101111110111	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
222	011111110111	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
223	111111110111	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
224	011011101111	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
225	111011101111	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX
226	010111101111	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX

227	110111101111	XXXXXXXXXXX	XXXXXXXXXXX	XXXXXXXXXXX
228	101111101111	XXXXXXXXXXX	XXXXXXXXXXX	XXXXXXXXXXX
229	011111101111	XXXXXXXXXXX	XXXXXXXXXXX	XXXXXXXXXXX
230	111111101111	XXXXXXXXXXX	XXXXXXXXXXX	XXXXXXXXXXX
231	111011011111	111011011111	XXXXXXXXXXX	XXXXXXXXXXX
232	010111011111	010111011111	XXXXXXXXXXX	XXXXXXXXXXX
233	110111011111	110111011111	XXXXXXXXXXX	XXXXXXXXXXX
234	101111011111	101111011111	XXXXXXXXXXX	XXXXXXXXXXX
235	011111011111	011111011111	XXXXXXXXXXX	XXXXXXXXXXX
236	111111011111	111111011111	XXXXXXXXXXX	XXXXXXXXXXX
237	111010111111	111010111111	111010111111	XXXXXXXXXXX
238	010110111111	010110111111	010110111111	XXXXXXXXXXX
239	110110111111	110110111111	110110111111	XXXXXXXXXXX
240	101110111111	101110111111	101110111111	XXXXXXXXXXX
241	011110111111	011110111111	011110111111	XXXXXXXXXXX
242	111110111111	111110111111	111110111111	XXXXXXXXXXX
243	010101111111	010101111111	010101111111	010101111111
244	110101111111	110101111111	110101111111	110101111111
245	101101111111	101101111111	101101111111	101101111111
246	011101111111	011101111111	011101111111	011101111111
247	111101111111	111101111111	111101111111	111101111111
248	101011111111	101011111111	101011111111	101011111111
249	011011111111	011011111111	011011111111	011011111111
250	111011111111	111011111111	111011111111	111011111111
251	010111111111	010111111111	010111111111	010111111111
252	110111111111	110111111111	110111111111	110111111111
253	101111111111	101111111111	101111111111	101111111111
254	011111111111	011111111111	011111111111	011111111111

In the example shown in the table, the first column corresponds to the video value to be rendered, the second column to the standard codeword (used in the standard area of the panel as described on Figure 18, the third, fourth and fifth respectively to the codeword used in the areas A1, A2, A3. In these three last columns, codeword xxxxxxxxxxxx means dropped codeword (not used).

For instance, in the area A1, the video values 33 up to 38 are not rendered whereas they are rendered in the two other areas.

Indeed, the video level 33 is rendered with the codeword 111010100000 in the standard area. In case of APL=0%, the 6th sub-field has an energy of 71 sustains which is more than A1 but lower than A2 and A3. In this codeword, the 6th sub-field is set to zero whereas the 7th is set to one,

which represents a critical situation as described in Figure
9. Therefore, the codeword is dropped for area Δ1 only.

Later on, the missing levels will be recreated by the means

5   of dithering. Even if this concept will increase a bit the
dithering noise in the border areas, it has to be remembered
that those areas are very small (e.g. 4% of screen size) and
do not represent the main area for the human eye. In that
case the limitations introduced by the specific border cod-

10 ing will not be really noticeable for the viewer but the
gain in terms of contrast (less priming used) will be quite
strong. Indeed, in the example at APL=0%, one signal priming
instead of 8 is enough, so that the contrast has been im-
proved by a factor 8.

15
Following number of levels are suppressed in the example:

Δ1:145 codewords are suppressed
Δ2:109 codewords are suppressed

20 Δ3: 79 codewords are suppressed

Moreover, fewer levels will be suppressed in the case of a
combination with dynamic priming. In that case, a trade-off
should be chosen between the number of sub-fields used for

25 dropping and the number of additional priming. The ideal
position for the primed sub-fields will be on the lowest
sub-fields from the critical group (all sub-fields having
more than Δn sustains) since the number of codewords to be
dropped will be more reduced in that case.

30
Furthermore, the suppression is done only for law APL values
as seen on Figure 17.

A hardware implementation of the border-coding concept for a

35 PDP panel is shown in Figure 19. Input 8-bit R, G, B is for-
warded to the video-degamma function block 1 (mathematical
function or LUT), which outputs the signal with more resolu-

tion (at least 10 bits). This signal is forwarded both to a
power measurement block 2 and to the video-mapping block 3.
The power measurement block 2 measures the Average Power
level APL of the video signal.

5

Depending on the Average Power Level (APL), the control sys-
tem 4 determines the sustain table and the encoding table
with its sub-fields number. Furthermore, this basic informa-
tion APL is sent to a border select block 5 so that a cor-
10 rect decision regarding the critical areas can be taken. To
do that, the border select block also disposes of position
information (H-line and Clock-pixel) so that the right Δ
area can be determined. Additionally, the border select
block 5 receives a control signal BORD from the system con-
15 trol block 4. This control signal BORD is used for activat-
ing the specific border coding. The Δ information output
from the border select block 5 as well as a mapping informa-
tion (related to the encoding and sustain table) is sent to
the video mapping block 3 which modifies the video data so
20 that the dropped video parts can be recreated correctly with
the dithering function.

After the mapping stage in video mapping block 3, data are
forwarded to a dithering block 6 replacing non-encodable
25 video levels. Then, the encoding to codewords of a 10 bit
RGB signal from the dithering block 6 is performed by the
sub-field coding block 7 receiving coding information from
the system control block 4 concerning the decision which LUT
should be used for sub-field coding.

30

The system control block 4 also controls the writing of 16
bit RGB pixel data from the sub-field coding block 7 in a 2-
frame memory 8 (WR), the reading (RD) of RGB sub-field data
from a second frame memory integrated in the 2-frame memory
35 8, and the serial to parallel conversion circuit (SP) in a
serial-parallel conversion block 9 receiving the output sig-
nals SF-R, SF-G,SF-B from the 2-frame memory 8.

The 2-frame memory 8 is required, since data is written
pixel-wise, but read sub-field-wise. In order to read the
complete first sub-field a whole frame must already be pre-
5   sent in the memory 8. In a practical implementation two
whole frame memories are present, and while one frame memory
is being written, the other is being read, avoiding in this
way reading the wrong data. In a cost optimized architec-
ture, the two frame memories are located on the same SDRAM
10   memory IC, and the access to the two frames is time multi-
plexed.

The serial-parallel conversion block 9 outputs top and bot-
tom data for the plasma display panel 10. Finally the system
15   control block 4 including an addressing and sustain control
unit 42 generates the SCAN and SUSTAIN pulses required to
drive the PDP driver circuits of the PDP 10.

In summary in this document, it was shown how the use of a
20   new coding concept can optimize the picture quality regard-
ing the contrast as well as the response fidelity. Subjec-
tive tests performed in dark room environment have shown
good picture quality assessment regarding classical PDPs.

25